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ABSTRACT

This report summarizes the findings of a study which used traditional input-output economic models merged with recent understandings of new growth theory to measure and assess both the static and dynamic economic impact of university research, especially in Canada. The study highlights were: (1) university research is a powerful stimulus for economic development, leading to measurable increases both in gross domestic product (GDP) and employment; (2) university research in Canada sustains $5 billion of GDP and results in more than 81,000 jobs, almost 1 percent of Canada's 1994-95 GDP and more than 0.5 percent of all the nation's jobs; (3) university research has a profound effect on the underlying productivity of the economy; (4) university research has the potential to produce breakthrough advances that can fundamentally alter economic growth and quality of life; (5) university research also has an economic impact by equipping students with the ability to generate new ideas and research skills; and (6) the total dynamic impact of university research in Canada amounts to around $15.5 billion each year, which corresponds to approximately 150,000 to 200,000 jobs. (DB)

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The Economic Impact of University Research

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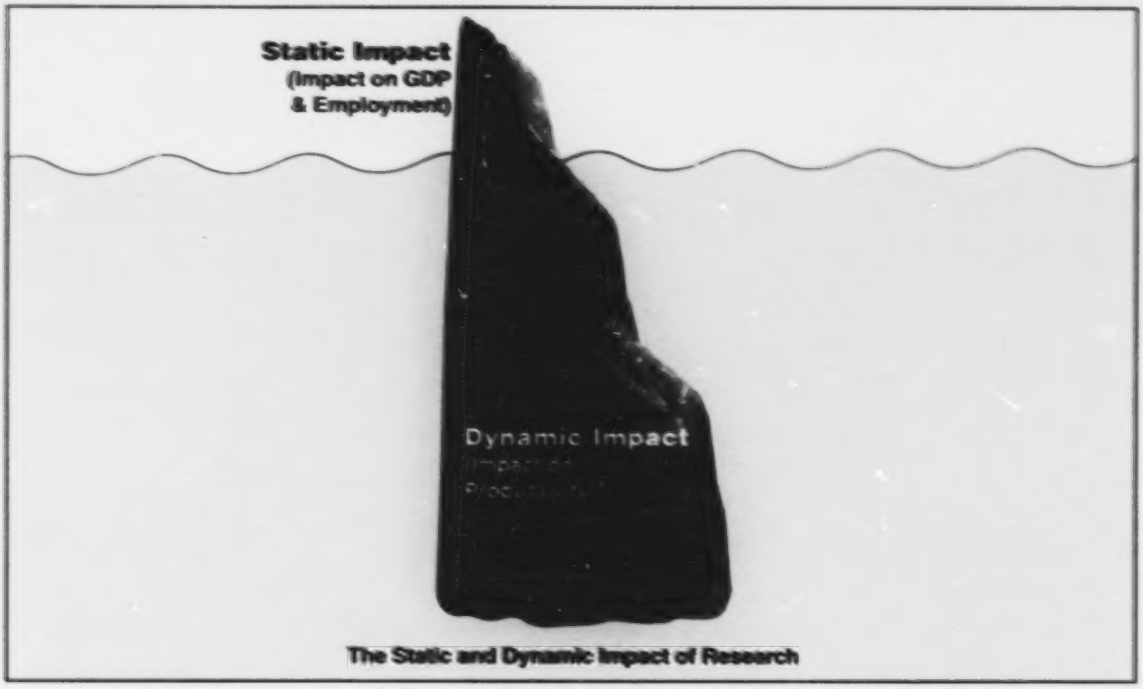
In business and economic circles, awareness is growing of the role of knowledge in stimulating economic growth. Accordingly, economists are adapting traditional growth models to account for the essential contribution of knowledge, and science and technology, in particular. Interest is likewise growing in how university research, which is society's largest source of knowledge, affects economic performance. This new study provides quantitative evidence of the contribution of university research to wealth creation. The study confirms that Canadian university research is a powerful stimulus for economic development, producing measurable increases in GDP and employment. More importantly, university research is shown to exert a dynamic and continuing impact on the underlying productivity of the economy, which carries forward into the future.

Note that even though this report emphasizes economic impacts, readers should also be aware that there are other critical benefits of university research that improve our quality of life.

For the purposes of this study, we estimated that expenditures on university research are $4.3 billion annually, and

Highlights

- University research is a powerful stimulus for economic development, leading to measurable increases both in GDP and employment.
- According to the traditional approach to measuring the gross economic impact, university research sustains $5 billion of GDP and results in more than 81,000 jobs. That translates to almost one per cent of Canada's GDP in 1994-95 and more than 0.5 per cent of all jobs — a significant impact for such a small sector of our economy.
- In addition to such static impacts, university research has a profound effect on the underlying productivity of the economy.
- University research has the potential to produce breakthrough advances that can fundamentally alter our economic growth and quality of life. And although not all research leads to such world-changing results, it does produce a steady stream of new ideas and technologies. These, in turn, lead to innovation and continuous improvements in productivity and quality of life.
- University research also has an economic impact by equipping students with the ability to generate new ideas. Companies benefit by hiring graduates with knowledge and research skills. University graduates help firms become more efficient and productive, and help them to introduce new products and processes.
- The total dynamic impact of university research amounts to around $15.5 billion each year. This corresponds to approximately 150,000 to 200,000 jobs.



As shown in this illustration, most of the impact of university research is not readily apparent.

that university research employs tens of thousands of people in Canada. In addition, nearly 75,000 thousand graduate students who are engaged in research spend more than $500 million a year on basic living expenses. Thus, total annual university research expenditures amount to approximately $4.8 billion. To put this spending in perspective, research expenditures at Canadian universities exceed the research expenditures of the top 15 private sector and crown corporations combined.

University research is truly a national undertaking. It is carried out at scores of institutions across the country. University researchers can be found working not only on university campuses, but at affiliated institutes and hospitals, as well as in industry and government labs.

This report summarizes the findings of a study which was commissioned by the Association of Universities and Colleges of Canada.[1] The study uses the traditional tools of economics, together with the recent understandings of new growth theory, to measure and assess the economic impact of university research.

Measuring the impact

Traditional economic impact studies measure the "static" or one-dimensional impacts of an economic activity. That is, they assess how spending on a particular activity — in this instance research — affects the rest of the economy. Economists frequently use input-output (I-O) models, such as the one developed by Statistics Canada, to accurately calculate the impact of an expenditure as it works its way though the economy.

I-O models are useful for analysing the static impact of research, but they do not describe its underlying, dynamic impact on the two primary factors of production, labour and capital. I-O models do, however, provide an accepted measure for comparing different investments.

As this paper will demonstrate, the gross static impact of university research is large, especially its effect on GDP and employment. But the static impact of research represents only the tip of an "impact iceberg". Just as most of the mass of a real iceberg lies beneath the surface, most of the impact of university research is not readily apparent.

Consequently, many people overlook the dynamic impact of research and focus only on its static impact.

The larger dynamic impacts of university research can be quantified by using new models of economic growth.

Table 1

Gross Static Economic Impact of University Research (1994-95)

COMPONENT	GDP at Factor Cost ($ billion)	Employment
University R&D Expenditures (direct+indirect+induced)	4.66	73,390
Student Sustenance Expenditures	0.31	8,032
Total	4.97	81,422

The static economic impact of research

In the first part of our study, the Statistics Canada Input-Output (I-O) model was used to measure the gross static impact of university research spending (Table 1). The model calculated that $4.8 billion of university research sustains $5 billion of Gross Domestic Product, and resulted in more than 81,000 full-time jobs. To put these results into perspective, this represents almost one percent of Canada's GDP in 1994-95, and more than 0.5 percent of all jobs, which is a significant impact for such a small portion of domestic economic activity.

Economists know that, while the Statistics Canada I-O model is a reasonably accurate depiction of the economy, it tends to over-estimate impacts. This is because some of its working hypotheses do not take into consideration the alternative use of resources. Some of the expenditures attributed to university research and student expenditures would have taken place in any event, and their effect must be removed from the calculations.

Moreover, the I-O model tends to over-estimate impacts because it does not take into account the degree to which government spending on university research — because it is largely financed by borrowing and taxation — raises interest rates and displaces other investment. The I-O model also does not take into account the impact of graduate students' foregone earnings.

Therefore, to calculate the *net* impacts of university research — those which can be attributed only to research activity — we need to adjust the gross economic impacts.

Indeed, when the sources of over-estimation are eliminated, we found that university research still stimulated a net addition to GDP of $1.5 billion and more than 13,000 jobs in 1994-95 (Table 2).

These corrections appear to reduce the economic impact of university research. However, it is important to recognize that most economic impact studies to which studies on university research may be compared do not attempt to calculate their net economic impact. If they did, their apparent impacts would likewise decline. What is impressive about university research is that it has a positive net impact on the economy, even after the majority of its static impacts are discounted.

The dynamic impact of research

I-O models treat all expenditures as having equal impact on the economy. I-O models would attribute the same static impact to a sports stadium as to genetics or new materials research. Thus, I-O models would calculate that a $4.3 billion research expenditure produces approximately the same economic impact as a $4.3 billion expenditure on sports stadiums. Yet we know that university research also has a measurable impact on long-term growth, through its impact on the *underlying productivity* of the economy. This is the dynamic impact of research.

Table 2

Net Static Economic Impact of University Research (1994-95)

COMPONENT	Gross GDP at Factor Cost ($ Billion)	Employment
Original Estimate	4.97	81,422
(Less Over-Estimate)	(3.46)	(67,845)
Net Impact	1.51	13,577

What is unique about university research is that it contributes heavily to the ability of other parts of the economy to improve the productivity of their labour and capital. In this respect it is an enabling activity. So, for example, both an individual research project and the construction of a sports stadium may have a comparatively small direct impact on GDP through the spending they generate in the economy.

But, unlike the stadium, the results of that research project, such as faster wireless communications technology or the mapping of the human genome, may have an enormous impact on future growth. Just as important as developing specific technology is the growth in the productivity of the workforce, since research training helps people acquire new knowledge and skills.

Some research projects have the potential to yield world-changing impacts and to fundamentally alter economic growth and quality of life. Many people believe that new fields of activity such as genetics or gene therapy and advanced industrial materials will have such consequences.

Of course, not all university research produces breakthrough advances. Much of it creates incremental additions to knowledge and technology. This steady stream of innovation also produces continuous improvements in productivity and quality of life.

Evidence of the dynamic impact of university research is not hard to find. The success of a number of rapidly growing "technopoles" (technological growth poles), provides evidence that the dynamic impacts are real. Cities everywhere are trying to emulate the success of well-known technopoles such as Silicon Valley or Route 128 outside Boston.

In Canada, we have equally successful technological growth poles such as Ottawa's Silicon Valley North, Montreal's concentration of pharmaceutical and bio-medical companies or Saskatoon's biotechnology and agri-food industry.

University research is society's most fertile environment for training people and generating new ideas.

In each city, leading-edge research is stimulating the formation of start-up companies and attracting international enterprises to build new research and manufacturing facilities. The companies are motivated by the desire to be close to the sources of knowledge. In fact, the rapid growth of each of the regional economies above is closely associated with one or more local universities, which provide the trained people and ideas that fuel the growth of companies. As a result, each of these technopoles is generating new, high-paying jobs.

Measuring the dynamic impact

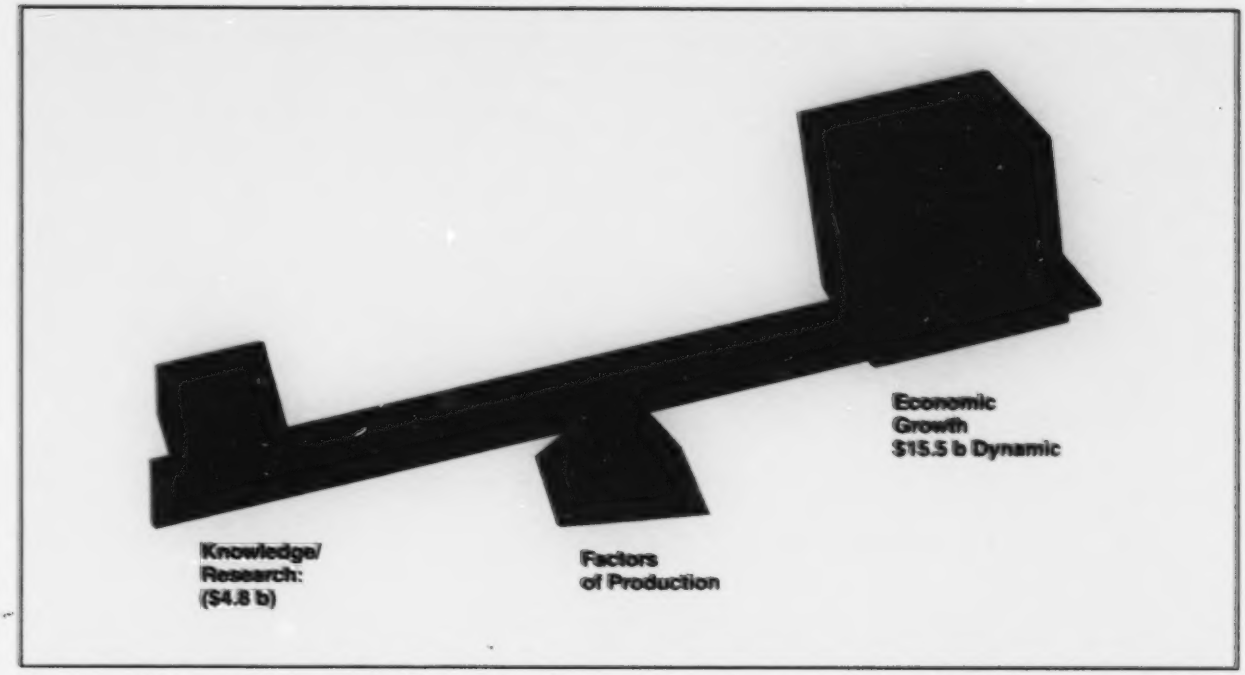
Until recently, the models and tools for measuring the economic contribution of universities have been limited. Traditional models of economic theory did not explicitly quantify the value of a country's research and development activity, and certainly not university research activity. Recent progress in economics, in particular what has come to be known as new growth theory, is supplying new models for understanding and measuring the true contribution of research to a national economy.

For many years, growth models attributed long-term economic growth to only two primary factors of production: labour and capital. Increases in the stocks of these determined the rate at which an economy would grow.

This classical growth model was eventually found to be lacking because it could not explain the tremendous rates of economic growth experienced by numerous countries after the Second World War. It became increasingly clear that another factor — technological change — was missing from the model. Technological change allowed GDP to increase without increasing the stock of capital or the amount of labour, because it made capital and labour more productive.

But technological change does not arise of its own accord. It is the result of the efforts of many skilled people. Without highly trained people, and the knowledge and skills they embody, there would be no technological change. And university research is society's most fertile environment for training people and generating new ideas.

In Canada, a high proportion of the workforce acquires its skill and knowledge in universities. Approximately 12 percent of the workforce has completed a university undergraduate program, and six percent have acquired a higher degree that exposed graduates to research training.



Even a small amount of knowledge from university research can leverage a comparatively large amount of GDP.

Thus, universities not only produce knowledge by undertaking research, they also equip individuals with the skills necessary to put knowledge to work. Indeed, many would say that the most important output of university research is people with knowledge and research skills. Organizations that hire employees with university research training profit from the knowledge and skills they bring to the workplace. These graduates help firms become more efficient and productive, and help them to introduce new products and processes. In these ways, university research increases the productivity of firms' labour and capital, which leads to higher GDP and job creation.

The illustration on this page shows, in a simplified way, how university research influences economic growth and can leverage a comparatively large amount GDP.

Aside from graduates, who bring their knowledge and expertise to a new work environment, universities disseminate knowledge to firms through research contracts, faculty consulting activities, publishing or technology licensing. Firms utilize the employees, knowledge and technology they acquire to increase the productivity of their capital and produce new products.

Studies in the U.S. have found that, increasingly, scientific papers cited in industrial patents have a university source.

In fact, studies in the U.S.[7] have found that, increasingly, scientific papers cited in industrial patents have a university source. As a result, more and more firms are supporting and commissioning research that is of interest to them. Universities are responding to the growing interaction with industry by bolstering their industry liaison and technology transfer offices.

There is convincing evidence that Canadian firms are more reliant on university research than their counterparts in the U.S. and abroad. Firms in Canada finance around 17 percent of all external research spending at universities[8], which is higher than in most other countries. Higher university research spending helps to compensate for Canadian firms' lower in-house R&D and gives firms access to leading-edge skills and expertise, which they find difficult to develop on their own.

Can we quantify this process? Assessing the impact of university research on GDP and jobs begins with measuring the impact

Table 3

Total Net Contribution of University R&D to GDP (1993)

Contribution to increased graduate productivity	$ 2.7 billion
Contribution to the productivity of other factors	$12.8 billion
Total Contribution	**$15.5 billion**

of research on the Total Factor Productivity (TFP) of an economy. TFP is the economic growth that results from increases in the efficiency and productivity of labour and capital. Much of the improvement in TFP results from advances in society's stock of knowledge, and an increase in the ability of the workforce to apply it. Thus, it is easy to see how important universities are to economic growth.

We know from OECD estimates[7] that TFP contributes about 20 percent of Canadian GDP growth, while growth in the stocks of labour and capital account for the rest. Therefore, in 1993 — our sample year — TFP accounted for about $73.1 billion of Canadian GDP and one million jobs. As the primary source of knowledge and skilled workers, university research is directly responsible for a significant portion of this growth and employment through its impact on TFP.

We can calculate the size of the contribution in the following way. As domestic R&D is responsible for approximately 69 percent of the increases in TFP, it follows that total Canadian R&D accounted for around $50.4 billion of GDP in 1993.

This amount is divided between the increase in the productivity of human capital (university graduates, higher degrees) that can be attributed to university research, and the increase of productivity of the other factors of production. The increase in earnings of the graduates is allocated to university research on the basis of its share in the total cost of producing a graduate. Supposing now that we can impute 35 percent of the supplementary gains of the graduates, valued at $7.7 billion, to the efforts of the university, we conclude that around $2.7 billion of the supplementary GDP is attributable to university research *per se*.

The total impact of university research amounts to approximately $15.5 billion each year, corresponding to approximately 150,00 to 200,000 jobs.

In turn, university research accounts for around 30 percent of total Canadian R&D. That implies that 30 percent of the increase in the productivity of the other factors of production, (i.e. $50.4 b. - $7.7 b. = $42.7 b. times 30%), or $12.8 billion of GDP in 1993, is also attributable to university research.

Therefore, the total impact of university research amounts to approximately $15.5 billion each year (Table 3), corresponding to approximately 150,000 to 200,000 jobs.

Conclusion

University research produces impressive and long-lasting economic dividends. New analysis confirms that Canada's annual university research investment is yielding large economic impacts, both in the static and dynamic dimensions. In the first instance, university research expenditure produces a gross increase of nearly $5 billion in GDP and more than 81,000 full-time jobs, from its original spending of $4.8 billion and employment of more than 40,000. Even a more conservative calculation yields a positive net increase of more than $1.5 billion of GDP and 13,500 jobs.

Impressive as the static economic impacts of university research are, they are but the tip of the iceberg. Beneath the surface, knowledge has an even greater impact on the factors of production, labour and capital. Through its contribution to increased total factor productivity, university research fuels over $15 billion of annual GDP increase and 150,000 to 200,000 jobs.

University research is the common denominator for knowledge creation and knowledge transfer in the economy. Its primary contribution lies in improving the productivity of labour. University training supplies students with knowledge, information and research skills. After they graduate from university and find employment, students become a primary source of innovation in the organizations they join.

University research also generates new science, technology and process improvements which become available to firms via contracts, consulting and publications. Firms use these outputs to improve the productivity of their capital and to create new products, processes and services, which result in new jobs, exports and, importantly, profits.

In addition to its measurable impact on the economy, university research contributes to economic and social well being of all Canadians. Whether in health, learning, justice, social cohesion, or a host of other domains, university research improves our quality of life.

The issue for society is not whether we can afford to invest in university research, but whether we can hope to prosper without it.

As Canada anticipates its future prospects, it needs to look upon university research as a powerful stimulant for economic growth and social development. In the final analysis, the issue for society is not whether we can afford to invest in university research, but whether we can hope to prosper without it.

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Endnotes

1. The full report, entitled *The Economic Impact of Canadian University R&D*, is available from AUCC Publications, 350 Albert St., Suite 600, Ottawa, ON K1V 9B6. Phone: (613) 563-3961 ext. 205; Fax: (613) 563-9745; or e-mail: (sales@aucc.ca).

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